

Performance of virtual operating systems over VMware Workstation 6



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ABSTRACT: A two stage study on the applications of virtual operating systems over the currently popular virtualised environment of VMware Workstation 6 was carried out. The current work addresses the findings generated during testing the performance of three different operating systems, Windows XP, Ubuntu Linux, Macintosh operating system and applications running under VMware's virtualized environment. The performance tests covered parameters such as: boot-up and shut-down response times, central processing unit and random access memory usage. Similar resources had to be configured for each of the operating systems to receive meaningful results. The experiments revealed that VMware performance as a virtualised platform was satisfactory. The results concluded that the Macintosh operating system proved to be the worst in performance as compared to Windows XP and Ubuntu Linux. Ubuntu Linux performed impressively in the virtual environment with minor constraints which are listed in the paper. Windows XP was the best virtual operating system for use over VMware's virtual environment from among the tested operating systems. This research provides a base for conducting further study in the area of virtualization such as depth of nesting of OSs in virtual environment, number of OSs that can be supported in VMware, security between various virtual OSs and between Virtual OSs and the external network environment.

Keywords: Operating Systems, Macintosh, VMware Workstation 6, Windows XP, Ubuntu Linux

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1. Introduction

Information Technology is growing very fast. There are changes in the way we use computers, manage and use our resources. The x86 computers were used initially to run only a single Operating System (OS) and just one or a few applications concurrently depending upon available hardware resources. It was possible to have multiple OSs on a computer system but only one active OS at a time i.e. it was only possible to boot with any one of the available OSs at a time. However, virtualization has made it possible to run multiple operating systems and multiple applications concurrently on a single machine, thereby helping businesses to run the latest technologies with overall economy in computing resources resulting from economies of scale. VMware defines Virtualization as a general layer that permits the running of a number of virtual machines, with various operating systems to run independently and concurrently on one physical machine. This is achieved by sharing of hardware resources among the virtual operating systems making it possible to run multiple virtual machines with a variety of operating systems simultaneously on a physical machine [1]. The concept of virtualization has been around in the world of IT since the 1960's [2], first made popular by the IBM 360 mainframe systems. As of today, virtualization mainly focuses on platform virtualization where there is one host OS and multiple guest OSs run simultaneously [2]. Keeping in view the growing popularity of virtualisation a need existed for users to identify the performance issues of different OSs and applications running on virtualised platforms. Next section discusses relevant literature reviewed to ascertain any gaps in the research of this area.

2. Literature Review

Virtualization permits running of greater number of operating systems and applications on fewer machines. It boasts on focusing on "Fewer machine more applications". Virtualization reduces the amount of idle processing power on today's machine, thereby reducing the overall hardware cost. Virtualization while beneficial comes with a greater possibility of Information

Technology (IT) security being breached [3]. Students could also build large and complex virtual networks and test environments of multiple servers with fewer physical resources for the purpose of testing. This has proved to be very useful since it significantly reduces the cost of setting up many physical machines [4]. Businesses in the IT sector save a lot on cost and thereafter resources while implementing virtualized systems.

They reduce from having hundred servers to having twenty servers and still manage the same tasks more efficiently and easily [5].

During mid January 2008, VMware released the public beta version of VMware Workstation 6. Benjamin Koe installed Ubuntu and Mac OS X on VMware Workstation 6. The base operating system used was Microsoft Windows XP. , Ubuntu Linux seemed to perform better as compared to Mac OS X, which was very slow. Keo’s study also described that the Mac OS X can only operate when one processor was allocated to it [6]. In an experiment conducted by Mark on VMware 6.x and Virtual PC 2007, the load times comparison of Microsoft Vista operating on the VMware 6.x and Virtual PC 2007 virtual environments was made. Microsoft Vista’s load time was 1 minute and 27 seconds when booted on Virtual PC 2007 and 48 seconds when booted on VMware 6.x. An article by Wei-Meng Lee published during September 2006, stated that “virtualization software such as Virtual PC and VMware do not support running non Intel based Macintosh operating system on Windows” [7]. In the light of these and other literature review, it was decided to further test the performance of different OSs and applications over VMware. Details of these are covered in the following section.

3. Current Research Details

This research tested the performance of virtual operating systems and applications running on VMware Workstation 6. VMware Workstation 6 was selected over XEN and Virtual PC since it was the most popular virtualization platform. Performances of two applications were also tested on three guest OSs namely: Ubuntu Linux, Microsoft Windows XP Home Edition, and Apple Macintosh OS X. The choice of application involved one open source and a Microsoft application to offset any inherent bias in the results. The primary research question related to how different operating systems and compatible applications performed in VMware’s Workstation6 virtualized environment [8]. Experiments were conducted and results recorded using the test environment covered in the next section.

This infrastructure was divided into two parts: the Base Environment (BE) consisting of the Base Hardware and the Base OS and the Virtual Environment (VE) consisting of the VMware workstation on which run the three virtual OSs. Figure1 shows both these environments. The test environment consisted of a dual processing 2.20GHz HP Pavilion dv9000 Laptop, with a RAM of 3.0GB, Hard Drive capacity of 250GB and a NVIDIA GeForce 8400 Graphics card. The base OS on this machine is a Windows Vista Premium edition. VMware Workstation ACE edition v6 is the virtual infrastructure, which hosts three virtual operating OSs namely, Windows XP Home Edition, Ubuntu Linux and Mac OS X. Table 1 below displays the Physical and Virtual OS and resources allocated to them.

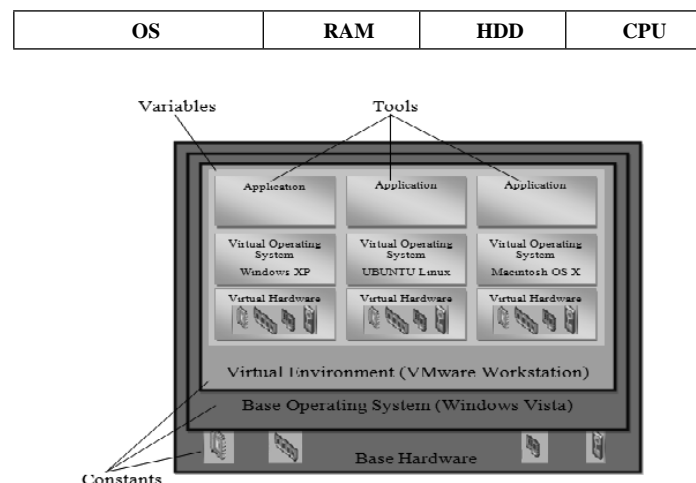


Figure 1. The Basic Test Environment

Physical Win Vista	3.0GB	250GB	2
Virtual Win XP	512 MB	6 GB	2
Virtual Ubuntu	512 MB	6 GB	2
Virtual MacOS X	512 MB	6 GB	1

Table 1. Operating Systems and allocated resources

4. Experiments, Findings and Results

This section presents results of the experiments after a brief description of each experiment. The three virtual OSs (Ubuntu Linux, Windows XP and Macintosh OS X) were successfully installed on the base OS (Windows Vista). While the overall deployment of the three virtual OSs was successful but there were a few limitations. The Macintosh virtual OS had issues connecting to the Local Area Network (LAN) and the wireless network. Therefore it was noted that the Macintosh virtual OS had limitations with regard to networking capabilities. The other virtual OSs were able to maintain the established virtual network connection. Each of the experiment below covers the aim, equipment used, process and finally the results obtained.

4.1. Experiment 1: System Load and Shutdown Time.

The aim of this experiment was to test the system start-up (load) time and the shutdown time for the OS's running on the physical system as compared to the same OS's running on the virtual platform configured with the same resources as on the physical system. Equipment used consisted of three physical systems each with Windows XP, Ubuntu Linux, and MAC OSX as the respective OSs. In addition use of a physical system with Windows Vista acting as a Host, while it ran; the three Virtual OSs, over VMware workstation virtual environment. A Digital Stopwatch was used to record the time. As for the process, in the first part of this experiment, the physical machine and the stop watch were started simultaneously so as to get an accurate result. Each physical OS's load time and shut down time was recorded for one OS at a time. In the second part of the experiment, the same stopwatch was used to record the start-up and shut down time for each of the three virtual (Vir) OSs. All three virtual OSs shared the same host OS which was Windows Vista. The results of the experiment are placed in the table below. In this experiment the resources recommended (as minimum requirement) considering the available resources of the physical (Phy) machine were used for each of the OSs.

OS	Boot	Shut	RAM	HDD	CPU
Phy Win XP	25 sec	21 sec	1.0GB	80GB	2
Phy Ubuntu Linux	40 sec	15 sec	512MB	80GB	2
Phy Mac OS X	32 sec	12 sec	1.0GB	80GB	1
Vir Win XP	29 sec	24 sec	512MB	6 GB	2
Vir Ubuntu Linux	43 sec	15 sec	512MB	6 GB	2
Vir Mac OS X	1m & 15sec	16 sec	1.5GB	6 GB	1

Table 2. Boot and Shutdown time with recommended resources

Table 3 below shows results of the experiment with same resources for each of the OSs. This table includes the system boot and shutdown time for the three OSs. This depicts the comparison of performance of the three OSs running on a physical system followed by the same OSs running in the virtual environment.

OS	Boot	Shut	RAM	HDD	CPU
Phy Win Vista	26 secs	18 secs	3.0GB	250G	2
Phy Win XP	27secs	22 secs	512MB	80GB	2
Phy Ubuntu Linux	40secs	15 secs	512MB	80GB	2
Phy Mac OS X	36 secs	15 secs	512MB	80GB	1
Vir Win XP	29 secs	24 secs	512MB	6.0GB	2
Vir Ubuntu Linux	43 secs	15 secs	512MB	6.0GB	2
Vir Mac OS X	1:28 secs	21 secs	512MB	6.0GB	1

Table 3. Boot and Shutdown time with similar resources

Experiment Limitations: Mac OS X did not boot when allocated two CPU's in the virtual environment. An equal amount of RAM was shared among the physical and virtual OSs with the exception of Microsoft Vista since it was the base OS. The Hard disk capacity was the same for the physical systems except Microsoft Vista since it hosted the virtual environment. The maximum hard disk capacity that could be allocated to the virtual machines was six gigabytes.

4.2. Experiment 2: System Load and Shutdown time in different sequence

The aim of this experiment was to establish if there was any affect on system load and shutdown times, on account of the boot and shutdown sequence of the guest OSs. Equipment used, was as before. The results for the possible 6 ways each for boot and shutdown are covered in Tables 4 & 5 below:

1 st OS	Boot	2 nd OS	Boot	3 rd OS	Boot
Ubuntu Linux	43 sec	Win XP	30 sec	Mac OS X	1:16
Ubuntu Linux	43 sec	Mac OS X	1:15 sec	Win XP	31
Win XP	29 sec	Ubuntu Linux	43 sec	Mac OS X	1:17
Win XP	29 sec	Mac OS X	1:17 sec	Ubuntu Linux	44
MacOS X	1:15 sec	Ubuntu	44 sec	Win XP	32
Mac OS X	1:15 sec	Win XP	31 sec	Ubuntu Linux	45

Table 4. Boot time in sequence

Table 5 below shows the shutdown time for the three virtual OSs, running on the virtual environment when prioritised to shut down first, second or third.

1 st OS	Shut	2 nd OS	Shut	3 rd OS	Shut
Ubuntu Linux	15	Win XP	24	Mac OS X	17
Ubuntu Linux	15	MacOS X	16	Win XP	24
Win XP	24	Ubuntu Linux	15	Mac OS X	17
Mac OS X	24	MacOS X	16	Ubuntu Linux	16
Ubuntu Linux	16	Ubuntu Linux	15	Win XP	24
Mac OS X	16	WinXP	24	Ubuntu Linux	17

Table 5. Shutdown time in sequence

4.3 Experiment3: Testing with Third party application

The aim of this experiment was to test the response times and usage of the shared resources by the virtual operating systems while executing third party applications. VLC Player application (Third party application) was used in addition to the equipment used for the previous experiment. The process involved, a third party application (VLC Player) being tested on both the virtual operating systems. The same application was installed on both the virtual operating systems namely Microsoft Windows XP and Ubuntu Linux. The applications were run on their respective operating systems. The load time for the application was recorded with the help of a stopwatch. The details of this experiment are covered below.

4.3.1 Experiment 3A: Load time of the Application:

Table 6 below, shows the load times of the application that was executed on each of the two operating systems one at a time. The results were recorded in three attempts. The frequency between the first attempt and the second attempt was fifteen minutes and the difference between the second attempt and the third attempt was of an hour. This was done to check the difference in the results on each execution. Normal usage of the operating system was maintained during the intervals.

Virtual OS	1 st Attempt	2 nd Attempt	3 rd Attempt
Virtual Windows XP	1.70	1.20	1.70
Virtual Ubuntu Linux	3.78	3.42	3.78

Table 6. Load time of VLC player (The results are recorded in seconds)

4.3.2 Experiment 3B: CPU usage by the application:

The aim herein was to test the CPU usage that was needed by the VLC application to execute itself in the virtual Windows XP operating system environment. The usage was noted from the average idle CPU usage by the virtual operating system (2.0 percent). It was also noted that the system used to conduct this experiment was a dual core processing system and the task manager demonstrated this as one processor in its CPU usage graph. UBUNTU's System Monitor was used to depict the amount of CPU usage that was needed by the VLC application to execute itself in the virtual Ubuntu Linux operating system environment. Since the system used to conduct this experiment was a dual core system, the System Monitor herein illustrated the usage of both the cores. In this case core one is displayed as CPU 1 and core two is displayed as CPU 2. This meant that Ubuntu Linux recognised the two cores as two separate processors unlike Windows XP which recognised them as one. It can be noted that the average CPU usage by the virtual operating system was 3.0 percent by the first core and 5.4 percent by the second.

UBUNTU System Monitor also provided a graphical reading that clearly showed CPU usage by the application to execute itself in the virtual Ubuntu Linux environment. Table 7 shows the percentage of CPU used by both the virtual operating systems in order to execute the VLC application. Three attempts were made and the observations noted for three tries of the application. The same principle in case of intervals between the measurements is applied here and keeping to the normal usage of the operating system during the intervals.

Vir OS	1 st Attempt	2 nd Attempt	3 rd Attempt
Vir Wind XP	43%	41%	43%
Vir Ubuntu	62%	60%	62%

Table 7. CPU usage to execute the VLC Application without networking

4.3.3 Experiment 3C: Memory (RAM) usage by the application:

For the purpose of the test, only the VLC application is considered. Table 8 below shows the amount of memory (RAM) used by the application. Three measurements were made and the observations noted. Since the results were in kilo bytes in the Windows Task Manager and mega bytes in the UBUNTU's System Monitor, the results in the table display both the values in megabytes for ease of comparison.

Virtual OS	1 st Attempt	2 nd Attempt	3 rd Attempt
Virtual Win XP	9.8MB (10,044k)	9.8MB (10,035k)	9.8MB (10,062k)
Virtual Ubuntu Linux	19.1MB (19,560k)	19.1MB (19,553k)	19.1MB (19,572k)

Table 8. RAM usage to execute VLC Application (units: mega bytes and kilo bytes)

5. Experiment 4: Testing with Open source application

Aim of this experiment was to test the utilisation of the shared resources used by the virtual operating systems (Windows XP and Ubuntu Linux) while executing an open source application (firefox Browser). Equipment used was same as used for previous experiments. As for the process this experiment, tested Firefox Browser on the virtual XP and virtual Linux operating systems. The same application was installed on both the virtual operating systems namely Microsoft Windows XP and Ubuntu Linux. Observations made for load time and the results recorded with the help of a stopwatch are covered in the sub sections below.

5.1. Experiment 4A: Load time of the Application

Table 9 shows the load times of the Firefox application that was executed within the virtual XP and virtual Linux operating system, one at a time. The results were recorded in three attempts.

Virtual OS	1 st Attempt	2 nd Attempt	3 rd Attempt
Vir Win XP	4.72	2.15	4.62
Vir Ubuntu	4.32	1.97	4.06

Table 9. Load time of Firefox browser without networking (units seconds.)

5.2 Experiment 4B: CPU usage by the application

The average CPU usage by the virtual Windows XP operating system was 2.0 percent. It was also be noted that the system used to conduct this experiment was a dual core processing system and the task manager showed this as one processor in its CPU usage graph. This task manager also showed the total and the available physical memory as well as the available system cache. The information other than CPU usage was not considered since the aim of this experiment was to test the CPU usage of the application in the virtual environment Table 10 shows the percentage of CPU used by both the virtual operating systems in order to execute the Firefox browser application. Three attempts were made and the observations were noted. The same principle in case of intervals between the measurements and normal usage is applied here.

Virtual OS	1 st Attempt	2 nd Attempt	3 rd Attempt
Vir Win XP	92%	91%	92%
Vir Ubuntu	68%	66%	67%

Table 10. CPU usage to execute the Firefox Application without networking

5.3 Experiment 4C: Memory (RAM) usage by the application:

Table 11 below shows the amount of memory (RAM) used by the application. Three measurements were made and the observations noted. This was done to check the difference in the results on each execution. Normal usage of the operating system was maintained during the intervals. As before since the results were in kilo bytes in the Windows Task Manager and mega bytes in the UBUNTU's System Monitor, the results in Table 10 display both the values in megabytes for ease of comparison.

Virtual OS	1 st Attempt	2 nd Attempt	3 rd Attempt
Virtual Windows XP	26.4MB (27,112k)	26.4MB (27,109k)	26.4MB (27,117k)
Virtual Ubuntu Linux	0.07MB (76.0k)	0.07MB (76.0k)	0.07MB (76.0k)

Table 11. Memory used by the Firefox Application without networking (units: mega bytes and kilo bytes)

6. Findings and Results

The boot time and shut down time revealed an increase by just 2 secs in the virtual setup for both booting and shutdown times over the OS when run directly over the conventional physical setup while configuring both setups with same resources. The physical Ubuntu Linux machine setup was 3 seconds faster to boot but used the same time to shut down. The Mac OS X times differed greatly with 1minute and 8 seconds faster to boot and 6 seconds faster to shutdown. Even with 1.5GB RAM in the virtual setup Mac OS fared worse than the physical set up with 1.0GB RAM. The authors feel that the reason for this was that VMware 6 was not designed to support Mac OS. It may however be noted that VMware Fusion that is designed to support Mac OS [9]. The other limitation in regard to Mac OS was the non support of the OS of the VLC and Firefox Browser applications. In a multiple virtual OS hosting environment there exists only a marginal difference (1sec) in the boot and shutdown times of virtual OSs depending upon which OS is booted first, second or third. However, it may be noted that the shutdown time for XP remained the same irrespective of the order.

It was observed that the VLC application executes faster on the windows XP OS as compared to Ubuntu Linux. The reason for this appears to be the requirement of WINE to run the application over Ubuntu. As regards the variation in the application execution times over the 3 different attempts was due to the second attempt carried out only 15 minutes after the first attempt files needed for execution being resident in the memory. As for the 3rd attempt which was after an hour the results were identical as in the first time. The CPU usage for this application was far lower(43%) over the XP while it was 62% over Ubuntu. The RAM usage in XP was nearly half of that required Ubuntu with all attempts giving the same results.

The Firefox browser application executed faster over the Ubuntu virtual OS as compared to XP due to the application being an open source application. As for the execution times over the 3 attempts no significant difference was noted. The CPU usage for Ubuntu being only 68% as compared to XP's use of 92% was significant. Same was true for the RAM usage being 26.3MB more for XP than over Ubuntu with the 3 attempts giving the same results.

In earlier studies it was reported that Mac OS wasn't designed to operate on dual processing machines, this study reveals that it is possible to run this OS by allocating only one of the two processors to the virtual Mac OS for it to run. Overall Win

XP proved to be most suitable virtual OS to run over VMware 6. Another feature was the ability of the XP virtual OS communication like drag and drop feature with the base Windows Vista OS not available with the Ubuntu OS.

7. Conclusion & Recommendations

This research concludes that VMware has proven to be an effective virtual environment platform for cost and performance effectiveness. VMware workstation 6 and its later versions seems an effective platform for analysing virtual system performance as compared to other virtual environments in the market. Few constraints that exist in the use of VMware, relate to functionality of some features of the virtual operating systems over VMware and the applications supported by the virtual operating systems. This research indicates that Macintosh OS proved to have the lowest performance as compared to Windows XP and Ubuntu Linux. Ubuntu Linux performed impressively on the virtual environment with minor constraints. Overall performance of Windows XP, OS proved to be very successful. This research provides a base for conducting further study in the area of virtualization such as nesting of OSs in virtual environment, number of OSs that can be supported in VMware, security between various virtual OSs and between Virtual OSs and the external network environment.

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